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**D Saikia**
Ph.D. Scholar, Department of Textiles and Apparel designing, Faculty of Community Science, AAU, Jorhat, Assam, India

**N Gogoi**
Professor, Department of Textiles and Apparel designing, Faculty of Community Science, AAU, Jorhat, Assam, India

**S Bhuyan**
Assistant Professor, Department of Textiles and Apparel designing, Faculty of Community Science, AAU, Jorhat, Assam, India

**LD Soraisham**
Ph.D. Scholar, Department of Textiles and Apparel designing, Faculty of Community Science, AAU, Jorhat, Assam, India

**Corresponding Author:**
**S Bhuyan**
Assistant Professor, Department of Textiles and Apparel designing, Faculty of Community Science, AAU, Jorhat, Assam, India

# Evaluation of physical properties of mechanically extracted *Musa acuminate* Fibre

**D Saikia, N Gogoi, S Bhuyan and LD Soraisham**

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**Abstract**
The global drive towards sustainable material development has prompted extensive exploration of renewable resources, including non-wood lingo cellulosic fibers from various plant sources and agro-industrial residues. Among these resources, banana cultivation, prevalent in tropical regions, generates substantial biomass waste, with significant potential lying in the above-ground components, such as pseudo stems and peduncles, as sources of valuable fibers. *Musa acuminata*, a banana variety, emerges as a noteworthy contributor to agro-industrial residue production, boasting compelling physical characteristics conducive to diverse end-use applications.

In this study, we embarked on the mechanical extraction of fibers from *Musa acuminata,* utilizing a specialized banana extractor machine. Our investigation revealed remarkable findings regarding the physical properties of these extracted fibers. The raw banana fibers exhibited a maximum length of 29.00 mm, signifying their potential for applications requiring long and resilient fibers. Furthermore, these fibers displayed an impressive diameter of 130.98 µm and a wall thickness of 6.25 µm, suggesting robust structural integrity. The tensile strength of the raw banana fibers was measured at 22.00 g/tex, underscoring their suitability for applications demanding strength and durability. In addition, these fibers exhibited an exceptional elongation of 2.43% and a density of 2.00 g/cc, attributes essential for applications requiring flexibility and lightweight properties. Moreover, the bleached banana fibers demonstrated good fineness, registering at 15.45 tex, making them particularly promising for use in textiles and fine materials. The study illuminates the promising physical properties of mechanically extracted fibers from Musa acuminata, offering a sustainable and versatile resource for a multitude of applications. These findings contribute to the burgeoning field of renewable materials, opening avenues for innovative and eco-conscious product development.

**Keywords:** Banana, *Musa acuminata,* extraction, physical properties

## Introduction

Mankind has been strongly dependent on plant fibres for all kind of purposes. In earlier days, natural fibres served animportant role to mitigate the everyday needs in a wide range of uses. But in recent years the arrival of synthetic products are dominating over the natural fibre, due to the low cost. Banana is one of the earliest and important fruit crops cultivated by man in tropical parts of the world. Banana is distributed in more than 120 countries, over an area of 48 lakh hectares, with an annual production of 99.99 million tons in the year 2011 (Indian Horticulture Database, 2011) [7]. Species such as *Musa acuminata* are well known for their fibre qualities. *Musa acuminata*, commonly known as the Wild Banana or Edible Banana, is a tropical plant species that holds significance not only for its delicious fruit but also for its versatile and valuable fibers (Kavitha, V., & G, A., 2021) [8]. *Musa acuminata*, often referred to as "banana fiber," have been utilized by various cultures for centuries due to their exceptional strength, durability, and flexibility. These fibers have a wide range of applications, spanning from traditional handicrafts and textiles to modern sustainable industries and has gained significant attention due to its remarkable mechanical properties and eco-friendliness (Sivaranjana, and Arumugaprabu, 2021) [9]. *Musa acuminata* is a large fast-growing, suckering evergreen plant that typically grows to 12-20’ tall in the tropics. Plants produce huge paddle-shaped leaves that grow to 6-10’ long. Leaf sheaths overlap to form a trunk-like pseudo stem (false stem) (Simmonds, 1962) [5]. In most part of India, the banana pseudo stems are thrown away as agricultural waste because most of the people are ignorant about the extraction of fibre and its utilization.Due to increasing awareness on natural fibres the extraction of fibre from banana pseudo stem is gaining momentum.The extraction of fibres from pseudo stem of banana plant required certain care to avoid damage.During the extraction process gummy substances which are non-cellulosic are removed and fibre is extracted.

**Materials and Methods**

*Musa acuminata* plant was selected and collected from Jorhat district, Assam to extract the fibres.

**Physical characteristics of the plant**

The average length and diameter of the banana plant were measured with the help of measuring tape, average weight of the cut plant were weighted in weighing balance. The moisture content of the psuedostem was determined by using TAPPI standard method. (Technical Association of Pulp and Papers Industry, USA).

**Extraction of Banana fibre**

The first step of mechanical extraction of banana fibre was the decortication process. The extractions of fibres from banana psuedostem were carried out with the help of banana extractor machine (Tech pro banana extractor machine). The banana fibre was extracted from the inner bark of a banana tree. The trunk of the banana is peeled manually. Peeled brown and green part (outer bark) was thrown away as waste. Remaining white colour (inner bark) was used to extract banana fibres. The peeled white portion (inner bark) was fed into the decortication machine having pressure roller and fibre separating mechanism. The fibre were separated by putting the sheath into the machine by to and fro movement by hand. The same process was repeated for further fibre extraction. The fibres extracted were washed in the running water properly, squeezed and kept for for sun drying.

**Fig 1:** Decortication machine

**Fig 2:** Decortication of banana fibre

**Fig 3:** Decorticated *Musa acuminata* fibre

**Degumming process**

In the degumming process, 1:30 liquor ratio was maintained. Retted fibres were treated with 3% sulphuric acid at room temperature for 15minutes (Ghosh *et al.*, 1994 and Ghosh *et al.*, 1988) [3, 4]. Finally, the fibres were free from gummy matter and kept for further use.

**Fig 4:** Degumming of fibre

**Fig 5:** Degummed *Musa acuminata* fibre

**Bleaching process**

Bleaching was carried out by using 5% hydrogen peroxide at temperature (80-95°C) for 45 min. at a material to liquor ratio 1:30. Then fibres were washed and dried (Ghosh *et al.*, 1994 and Ghosh *et al.*, 1988) [3, 4].

**Fig 6:** Bleaching of fibre

**Fig 7:** Bleached *Musa acuminata* fibre

### Physical analysis of the extracted *Musa acuminata* fibre

### Morphological properties

The length, diameter and wall thickness of mechanically extracted *Musa acuminata* were determined according to ASTM standard method. Fibre was taken and gently straightens over the slide with the help of forceps. The medicinal paraffin was used to control the fibres to measure the individual length of fibres. It was possible with good lighting, a microscope slide over and Dokuval photo microscope scale (JEOL, Japan). The length of the fibre was recorded. The diameter and wall thickness of the fibre were also measured at the same time.

### Mechanical properties

### Tensile strength (g/tex) and elongation (%)

The tensile strength (tenacity) of fibres was measured on stelometer by taking a bundle of fibres of 25cm long and measure of tenacity at ½ gauge lengths. The breaking load was indicated by the pointer which moves over the large scale graduated from 0-10kg load. The tensile strength of fibres bundle was calculated according to (Booth, 1968) [2].

$$\text{Tensile strength (g/tex)} = \frac{\text{Breaking load}}{\text{Bundle weight (mg)}} \times 125$$

### Density (g/cc)

After degumming and bleaching, fibres were combed out and were taken for density test. The fibres were cut into fine pieces with the help of sharp scissor. Then samples were inserted separately in measuring cylinder up to a level of l0ml. After that the fibre were taken out and weighted in electronic balance. The density was expressed in gm/cc.

### Fibre fineness (tex)

A Single fiber was taken to measure the fibre fineness. The fineness of *Musa acuminata* fibers was determined by using a microscope (single fiber fineness tester) and torsion balance. Microscope works on the theory of vibrating strings to measure the fineness of individual fibers.

## Results and Discussion

**Table 1:** Physical characteristics of *Musa acuminata* plant

| Sl. No. | Particulars | Measurement |
|---|---|---|
| | | ***Musa acuminata*** |
| 1. | Length (m) | 4 |
| 2. | Diameter (cm) | |
| | A) Top | 85 |
| | B) Middle | 95 |
| | C) Bottom | 100 |
| 3 | Weight of the psuedostem (kg) | 27 |
| 4 | No. of leaves in psuedostem | 12 |
| 5 | Moisture content,% (psuedostem) | 93.2 |

From the Table 1 it was cleared that the average length of *Musa acuminata* plant was 4m. The diameter of the plant was taken by dividing the whole plant length into three parts *viz.* bottom, middle and top. The highest diameter of 100 cm was noticed in bottom part of the plant followed by middle 95 cm and top 85 cm.The average weight of the psuedostem of *Musa acuminata* was noted as 27 kg. There were12 nos of leaves in *Musa acuminata* plant and the moisture contents of the*Musa acuminata* psuedostem were found as 93.2 percent.

### Physical properties of *Musa acuminata* fibre

### Morphological properties

The morphological properties of fibers, such as fiber length, diameter, and wall thickness, play a crucial role in determining their strength and durability. The morphological properties such as length, diameter and wall thickness of *Musa acuminata* fibres were investigated in the present study and bestowed in the Table 2.

**Table 2:** Morphological properties of mechanically extracted *Musa acuminata* fibre.

| Parameters | Mechanical extraction | | |
|---|---|---|---|
| | **Raw** | **Degummed** | **Bleached** |
| Length (mm) | 29.00 | 25.66 | 20.86 |
| Diameter (µm) | 130.98 | 128.90 | 125.22 |
| Wall thickness (µm) | 6.25 | 5.85 | 3.30 |

Table 2 revealed that highest length was found in raw fibre as 29.00mm followed by degummed 25.66 mm and bleached as 20.86 mm fibre. Similarly, maximum diameter and elongation was observed in raw fibre as 130.98 µm and 6.25 µm respectively. The result revealed a decreasing trend of morphological properties from raw fibre to the bleached fibre. It might be due to the removal of extraneous materials from the raw fibre as these fibres undergone chemical treatment during degumming and bleaching process.

### Mechanical properties

Mechanical properties play a crucial role in the performance and utility of fibers. The mechanical properties such as tensile strength, elongation, density and fineness of mechanically extracted *Musa acuminata* fibre was analyzed and presented in the Table 3.

**Table 3:** Mechanical properties of mechanically extracted *Musa acuminata* fibre.

| Parameters | Mechanical extraction | | |
|---|---|---|---|
| | **Raw** | **Degummed** | **Bleached** |
| Tensile strength (g/tex) | 22.00 | 20.25 | 18.65 |
| Elongation (%) | 2.43 | 1.50 | 0.98 |
| Density (g/cc) | 2.00 | 1.04 | 0.88 |
| Fibre Fineness(tex) | 32.66 | 20.87 | 15.45 |

It was evident from the Table 3 that in mechanically extracted *Musa acuminata* fibre, highest (22.00 g/tex) tensile strength was found in raw *Musa acuminata* fibre and lowest in bleached (18.65 g/tex) fibre. Regarding elongation and density highest (2.43% and 2.00 g/cc) was noted in raw *Musa acuminata* fibre and lowest in bleached (0.98% and 0.88g/cc) fibre respectively. In case of fibre fineness, highest (15.45 tex) was found in bleached *Musa acuminata* fibre and lowest (32.66 tex) in raw fibre. The results showed a decreasing trend in the mechanical properties from raw to bleached fibres of *Musa acuminata* fibre which might be due to the different wet processing treatments carried out during investigations. The variations in the results in mechanical properties of banana fibres may also be attributed to the fact that natural fibres are subject to lack of uniformity and variation in quality due to climatic conditions and season. Regarding fibre fineness, as the value decreases, fineness of the fibre increases from raw to bleached in *Musa acuminata* fibre. The improved fineness in bleached fibre of both the fibres may be due to removal of cellulose, lignin and hemicellulose from the fibre.

## Conclusion

In conclusion, *Musa acuminata*, offers a remarkable and versatile source of natural fiber that holds immense potential for various applications. The fiber derived from the pseudostems of these plants has shown to possess desirable characteristics such as high tensile strength, fineness, biodegradability and abundance. With the growing scarcity of biodegradable fibres, these plant fibres could suitably be used as alternative source of synthetic fibres. In recent times, scientific research has gone deeper into the properties and potential uses of *Musa acuminata* fiber. Its applications span a wide range of industries, including textiles, paper production, biodegradable packaging, and even in the reinforcement of composites. The biodegradable nature of this fiber is of particular significance in the current global context of sustainable and eco-friendly materials.

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